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DIVISION OF POULTRY HUSBANDRY

WHEAT GRAY SHORTS FOR THE PREVENTION OF SLIPPED TENDONS IN BATTERY BROODER CHICKS

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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Rations containing wheat gray shorts milled from hard wheat produced fewer slipped tendons and more rapid gains than rations containing shorts milled from soft wheat when fed to chicks in battery brooders, although the units of feed necessary to produce a unit of gain in live weight were greater for the shorts milled from hard wheat than for the shorts milled from soft wheat. Hard wheat shorts contain larger amounts of protein, fat, ash, and fiber than soft wheat shorts but the soft wheat shorts contain more nitrogen-free extract than the hard wheat shorts.

The substitution of twenty percent wheat gray shorts in chick rations for a like amount of ground corn or ground kafir produced more rapid gains and fewer slipped tendons, and required less feed to produce a unit of gain in live weight than did rations not containing wheat gray shorts. Chick rations containing thirty percent wheat gray shorts produced more rapid gains but required more feed to produce a unit of gain in live weight than did rations containing twenty percent wheat gray shorts. The presence of twenty percent of wheat gray shorts in the rations containing 1.20-1.62 percent calcium and .56-.72 percent phosphorus had a greater effect in increasing the rate of gain, in reducing the number of chicks developing slipped tendons, and in reducing the units of feed required to produce a unit of gain in live weight than did any of the variations in the percentages of calcium and phosphorus studied. Rations containing 1.90-1.93 percent calcium and .87-.99 percent phosphorus, even though protected by twenty and thirty percent wheat gray shorts, produced more slipped tendons than did rations containing 1.20-1.62 percent calcium and .56-.57 percent phosphorus.

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Poultrymen are finding as they change to more intensive methods of broiler production, including the use of battery brooders, that it is important to select the proper feeds in order to prevent slipped tendons (sometimes called perosis) and to produce rapid and efficient gains. The condition known as slipped tendons occurs largely from the fourth to the seventh week in the growth period of chickens grown in battery brooders. The symptoms of slipped tendons in the advanced stages are these: the tibial-metatarsal joint is swollen and has a bluish-green color caused apparently by small hemorrhages in the underlying tissue, the tendons slip out of place to either side, and the use of one or both legs is partially or wholly lost. Whether or not the chicken is marketable depends on the severity of the deformity.

Previous Work

Titus and Ginn (17) and later Titus (16) found that rice bran is especially valuable in the prevention of slipped tendons or perosis. Titus (16) also reported that rice bran contains a factor, possibly a vitamin, which is necessary for normal bone development in chickens. He suggests that this might be one of the vitamin B complex; since it is not soluble in ether, it cannot belong to the group of fat soluble vitamins. Hunter and associates (8) were able to produce "hock disease" experimentally in more than ninety percent of the birds. They produced the abnormality readily by the addition of bone meal, sodium phosphate, and calcium carbonate to the basal ration. They said that the condition was more prevalent with chicks in batteries and concluded that for the prevention of "hock disease" oats or oat feed possess beneficial properties which could not be explained on the basis of their fiber content. Graham and associates (3) in an attempt to isolate the factor influencing the rate of growth, feather growth, and perosis, made a number of extracts of wheat germ middlings. Their results indicate that at least part of the activity of wheat germ middlings may be removed in solvents of a slightly acid nature. They also stated that it appeared that the success of wheat germ middlings in chick rations may rest upon at least three factors, one increasing rate of growth, another reducing mortality, and a third reducing slipped tendons. Branion (1) reported that perosis was common in chickens fed rations composed largely of corn and that this trouble was prevented to a considerable extent by the use of wheat germ, oat hulls and germ, or whole oats.

Wilgus and associates (19) found that a level of one percent phosphorus produced as severe perosis as larger amounts when steamed bone

meal was added as the phosphorus supplement to a basal ration containing .95 percent calcium and .81 percent phosphorus and low in the preventive factor. They estimated the relative perosis-preventing properties of common poultry feed stuffs to be as follows: wheat germ 100, wheat standard middlings 65, red dog flour 50, wheat bran 40, ground oats 30, hard wheat 5, soybean oil meal 0. They also stated that all but a small amount of perosis was prevented by feeding twenty percent wheat standard middlings when the phosphorus level was 1.2 percent. Sherwood and Couch (14) reported that when twelve percent of dried milk in rations containing about .51 percent phosphorus was replaced by a like amount of meat and bone scrap, thus raising the amount of phosphorus to about .95 percent, the percentage of slipped tendons was increased from fourteen to eighty-four. Rice bran and wheat gray shorts when incorporated in a ration in place of ground corn definitely prevented slipped tendons at phosphorus levels up to nearly 1 percent. It was found that two or more factors are associated with the trouble known as slipped tendons, and that there are indications that phosphorus is a causative factor and that a preventive factor is present in appreciable amounts in wheat gray shorts and rice bran and possibly in lesser amounts in oat groats and cottonseed meal.

Milby (10) found a correlation coefficient of .6303 between the percentage of phosphorus in the ration and the development of slipped tendons. He states, however, that his results did not justify the conclusion that phosphorus is the chief causative factor of slipped tendons, but merely indicates that high percentages of slipped tendons are associated with a high phosphorus content in the ration. Milby (11) later concluded that in rations otherwise adequate, excess phosphorus appears to be the chief causative factor in the production of slipped tendons. He found that rice bran and, to a lesser extent, wheat middlings appear to contain a substance which tends to prevent slipped tendons. The balance between the amount of phosphorus and the preventive factor seems to determine the development of slipped tendons. He also found that a ration containing three percent of magnesium carbonate did not cause slipped tendons but did cause slower growth and a lower ash content of femurs. Hammond (4) in studies of inorganic phosphorus as related to perosis, recorded that "the highest correlation was found between inorganic phosphorus and perosis. There was a high correlation between perosis and total phosphorus, but a significant negative correlation between organic phosphorus and perosis. The use of partial correlations showed there was also a significant negative correlation between perosis and calcium." He stated further "that inorganic phosphorus is a primary factor in the etiology of perosis."

Insko and associates (9) found that a widening of the calcium-phosphorus ratio did not increase the percentage of slipped tendons. An increase of bone meal in the feed, which involves an increase of phosphorus, although the calcium-phosphorus ratio remained about the same,

caused a noticeably higher percentage of slipped tendons. The phosphorus in bone meal is largely inorganic phosphorus. Payne and associates (12) concluded that intensive brooding methods may be a contributing factor in the development of slipped tendons in connection with rations in which the minerals are not properly balanced. He reported that purified calcium-phosphate and calcium-carbonate gave the same trouble as did steamed bone meal. He suggested that an attempt to avoid rickets by the use of calcium and phosphorus is likely to produce slipped tendons. Buckner and associates (2) found that the addition of magnesium carbonate to chick rations produced abnormal conditions of the leg bones. This was more marked when fed with tricalcium phosphate than without it. Herner and Robinson (7) reported that the amount of leg troubles increased when increasing amounts of meat meal ash were used in the rations. Heller and associates (5, 6) presented data to show that perosis cannot be cured by the usual vitamin treatment but by a phosphorus correction of the diet. Sherwood (13) reported that the percentage of slipped tendons was increased by increased amounts of total phosphorus or decreased amounts of calcium in the ration.

Method of Procedure

Four specific studies are reported in this bulletin. The general methods of procedure are similar for the different studies. The chickens used were Single Comb White Leghorns of like breeding produced from stock raised by the poultry division of the experiment station. They were all hatched at the station in the same incubator.

In the lots for these experiments, the chicks were distributed at random; but the largest and the smallest chicks as well as any weak ones were discarded. The chicks were weighed at the beginning and at the end of the experiments and at two week intervals. They were weighed early in the morning after feed had been withheld since six o'clock the preceding afternoon. The chicks were fed in battery brooders so placed in a well ventilated brooder room that all lots were under as uniform conditions as possible. The feed was weighed daily and the chicks were allowed about all they would consume. Tap water was before them at all times. The chicks in experiment 1 had approximately an eleven hour feeding period per day, while in all of the other experiments the feeding period was fourteen hours per day.

Samples of feed used in these experiments were analyzed by the Division of Chemistry; these analyses are given in Table 1.

The units of feed required to produce a unit of gain in live weight, (sometimes called feed efficiency) as used in this work, are calculated by dividing the total weight of the feed intake for the chicks in a lot by the total gains made by the individuals of that lot.

In calculating the slipped tendon index, a method similar to that reported by Titus and Hammond (18) for their perosis index was used.

Table 1—Percentage composition of feeds

Feed	Sample No.	Protein	Fat	Crude Fiber	Nitrogen Free Extract	Moisture	Ash	Calcium	Phosphorus	Magnesium	Insoluble Ash
Ground kafir	98	12.65	2.70	1.90	71.14	10.03	1.58	.03	.34	.....	.16
Ground yellow corn	101	9.60	4.25	1.97	72.08	10.84	1.26	.01	.29	.....	.09
Alfalfa leaf meal	100	20.46	3.26	17.97	39.73	7.72	10.86	1.71	.24	.....	1.37
Alfalfa leaf meal	104	21.63	3.27	20.32	37.62	6.53	10.63	1.52	.31	.....	1.27
Wheat gray shorts	99	21.45	4.03	5.22	54.28	10.59	4.43	.14	.90	.....	.30
Wheat gray shorts	102	20.30	5.26	6.71	52.98	10.09	4.66	.13	.98	.....	.07
Hard wheat gray shorts	108	20.48	4.18	6.14	55.64	9.11	4.45	.14	.84	.32	.14
Soft wheat gray shorts	109	14.88	3.69	2.92	67.11	9.12	2.28	.06	.50	.16	.05
Blended wheat gray shorts	110	19.48	4.50	4.31	58.72	9.57	3.42	.11	.76	.28	.07
Dried buttermilk	96	31.80	5.86	.08	43.97	8.80	9.49	1.69	1.00	.....	.09
Dried buttermilk	103	44.35	7.14	.83	26.85	8.39	12.44	2.53	1.13	.....	.07
Meat and bone scrap	113	51.39	8.35	2.66	.17	5.29	32.14	11.32	5.46	.26	.43
Ground oyster shell	95	.....	.....	.....	.....	.....	.....	38.45	.....	.....	.51
Ground oyster shell	106	.....	.....	.....	.....	.....	.....	39.18	.....	.....	.15
Bone meal	97	25.73	1.43	.70	2.06	6.00	64.08	24.18	11.23	.....	.11
Bone meal	112	26.48	4.69	.69	2.73	5.67	59.74	22.97	10.54	.50	.05

Table 2—Ingredients of rations used in experiment 1 including calcium and phosphorus

Feed	Sample Number	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6
		Percentage of ingredients in rations					
Wheat gray shorts	99	20.00	20.00	20.00	.00	.00	.00
Ground kafir	98	53.87	52.65	53.34	73.34	72.13	72.87
Alfalfa leaf meal	100	5.00	5.00	5.00	5.00	5.00	5.00
Dried buttermilk	96	18.00	18.00	18.00	18.00	18.00	18.00
Ground oyster shell	95	2.00	1.97	1.28	1.28	1.24	.50
Bone meal	97	.00	1.25	1.25	1.25	2.50	2.50
Salt	.....	1.00	1.00	1.00	1.00	1.00	1.00
Cod liver oil	.....	.13	.13	.13	.13	.13	.13
		Calcium and phosphorus analyses of rations					
Percent calcium		1.20	1.49	1.23	1.21	1.49	1.21
Percent phosphorus		.56	.69	.69	.58	.72	.72
Calcium-phosphorus ratio		1:.47	1:.46	1:.56	1:.48	1:.48	1:.60

Table 3—Ingredients of rations used in experiments 2 and 3 including calcium and phosphorus

Feed	Sample Number	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6
		Percentage of ingredients in rations					
Wheat gray shorts	102	20.00	20.00	20.00	.00	.00	.00
Ground yellow corn	101	53.87	52.65	53.34	73.34	72.13	72.87
Alfalfa leaf meal	104	5.00	5.00	5.00	5.00	5.00	5.00
Dried buttermilk	103	18.00	18.00	18.00	18.00	18.00	18.00
Oyster shell	106	2.00	1.97	1.28	1.28	1.24	.50
Bone meal	112	.00	1.25	1.25	1.25	2.50	2.50
Salt	.....	1.00	1.00	1.00	1.00	1.00	1.00
Cod liver oil	.....	.13	.13	.13	.13	.13	.13
		Calcium and phosphorus analyses of rations					
Percent calcium	.....	1.35	1.62	1.35	1.33	1.60	1.31
Percent phosphorus	.....	.57	.69	.70	.57	.70	.69
Calcium-phosphorus ratio	.....	1:.42	1:.43	1:.52	1:.43	1:.43	1:.53

The chicks were graded as normal, and as slight, medium and bad cases of slipped tendons. Values of zero, one, two, and three were given to the respective grades. These values were added, the sum was divided by three times the number of chicks in the lot, and this figure was multiplied by 100. The figure obtained is the slipped tendon index, and of course the larger the index the more severe the trouble.

Experimental Results

Comparison of No Wheat Gray Shorts with Twenty Percent Wheat Gray Shorts

This study was planned to supply more information on the value of wheat gray shorts in controlling slipped tendons and in influencing gains and the units of feed required to produce a unit of gain in live weight. The substitution of twenty pounds of wheat gray shorts for a like amount of ground kafir or ground corn was studied on three levels of calcium and phosphorus. The changes in calcium were made by varying the amounts of oyster shell and bone meal while the changes in phosphorus were made by varying the amount of bone meal in the rations. As these mineral feeds were changed the amounts of ground kafir or ground corn were changed accordingly, because kafir and corn were the lowest in mineral content of all the feeds studied.

Table 2 gives the rations used in experiment 1 of this study and Table 3 gives the rations used in experiments 2 and 3. The only difference between them is that ground kafir was used in experiment 1 and ground corn in experiments 2 and 3. In this study it is not known whether the wheat gray shorts used were milled from hard wheat or soft wheat. However, the chemical composition is more nearly like that of shorts milled from hard wheat than it is like the composition of shorts from soft wheat. No attempt was made to make the protein, carbohydrate, and fat content of the different rations exactly the same; however, the differences in the percentages of these nutrients in these rations were not large. It was planned in this study to have the total amounts of calcium and phosphorus of the rations containing shorts as nearly the same as those of the respective rations not containing shorts as was possible.

Results

It is seen from table 4 that on all mineral levels in every experiment the slipped tendon index was much lower when twenty percent of wheat gray shorts was included in the rations than when no shorts was fed. The slipped tendon index for the lots with twenty percent wheat gray shorts ranged from 0 to 9.4 with an average of 2.5. The slipped tendon index for the lots without wheat gray shorts ranged from 13.5 to 43.7 with an average of 33.8 (Table 4). The difference in the slipped tendon index for the lots on the same mineral levels of each experiment caused by the use of wheat gray shorts ranged from 11.3 to 40.7 (Table 5). The rations containing low calcium and low phosphorus showed a smaller

Table 4—Slipped tendon index, average gain in live weight in grams and feed efficiency experiments 1, 2, and 3

	Low calcium Low phosphorus		Low calcium High phosphorus		High calcium High phosphorus	
	Ration 4 No wheat gray shorts	Ration 1 20 percent wheat gray shorts	Ration 6 No wheat gray shorts	Ration 3 20 percent wheat gray shorts	Ration 5 No wheat gray shorts	Ration 2 20 percent wheat gray shorts
	Slipped tendon index					
Experiment 1	13.5	2.2	39.7	0.8	40.7	0.0
Experiment 2	22.2	2.2	42.2	3.0	33.3	9.4
Experiment 3	29.4	2.4	43.7	1.7	39.7	0.9
Mean of experiments 2 and 3	25.8	2.3	43.0	2.4	36.5	5.2
	Average gain in live weight in grams					
Experiment 1 Cockerels	659.7±15.2	810.2±20.1	690.6±14.1	837.9±12.8	707.4±15.2	901.0±14.0
Experiment 2 Cockerels	783.3±22.2	984.9±25.4	757.3±31.8	1072.3±23.0	801.6±25.0	1103.3±32.4
Experiment 3 Cockerels	829.4±27.9	1011.1±21.3	818.4±21.0	1079.8±27.5	809.7±33.6	1097.8±18.8
Mean of experiments 2 and 3	805.1±17.6	1000.2±16.2	791.4±18.4	1076.4±18.0	805.3±20.3	1100.2±17.5
Experiment 1 Pullets	613.6±11.1	677.9± 9.9	562.6± 8.4	710.0±11.3	607.6±10.7	705.0±13.0
Experiment 2 Pullets	691.9±23.7	808.9±24.2	700.3±14.1	880.7±20.1	773.8±16.7	886.5±19.1
Experiment 3 Pullets	721.3±19.7	840.7±17.8	667.5±18.2	846.4±23.1	697.4±13.8	856.2±39.2
Mean of experiments 2 and 3	710.5±15.1	828.0±14.3	682.6±11.8	861.5±15.6	728.7±11.3	870.5±22.6
	Units of feed required to produce a unit of gain in live weight					
Experiment 1	4.26	3.77	4.12	3.86	4.05	3.74
Experiment 2	4.26	4.34	4.38	3.95	4.18	3.93
Experiment 3	3.99	3.95	4.03	3.74	4.10	3.85
Mean of experiments 2 and 3	4.13	4.15	4.21	3.85	4.14	3.89

difference in the slipped tendon index between the lots receiving wheat gray shorts and those not receiving it, than did the rations containing low calcium and larger amounts of phosphorus. It is true that none of these rations contained as large amounts of phosphorus as is sometimes fed, especially in rations containing meat and bone scrap, or larger quantities of bone meal; therefore, the corrective effect of the shorts, even on the highest levels of phosphorus studied in these experiments. is more pronounced than in some other experiments where the phosphorus levels are so high that a considerable number of chickens develop slipped tendons, even when fed wheat gray shorts.

It is seen in Table 4 that in every case (with both cockerels and pullets and on all three mineral levels) the increases in gains due to the use of wheat gray shorts are significant. The difference in gains caused by wheat gray shorts regardless of the mineral levels fed was from 147.3 to 315.0 grams for cockerels, with an average of 226.8 grams. With pullets this difference of gains caused by use of wheat gray shorts ranged from 64.3 to 180.4 grams with an average of 131.7 grams. Table 5 shows that as regards the lots on the same mineral levels the increases of gains caused by twenty percent wheat gray shorts ranged from 147.3 to 294.9 grams for cockerels and from 64.3 to 178.9 grams for pullets. The chicks receiving wheat gray shorts required less feed to produce a unit of gain in live weight than did those not receiving wheat gray shorts in every experiment and on all levels of calcium and phosphorus except with the chicks fed the low calcium-low phosphorus rations of experiment 2 (Tables 4 and 5).

Table 5—Summary of advantages of wheat gray shorts

	Advantages* of rations with 20 percent wheat gray shorts over rations with no wheat gray shorts		
	Low calcium and low phosphorus rations	Low calcium and high phosphorus rations	High calcium and high phosphorus rations
	Slipped tendon index		
Experiment 1	11.3	38.9	40.7
Experiments 2 and 3	23.5	40.6	31.3
	Average gain in live weight in grams		
Experiment 1 Cockerels	150.5±25.2	147.3±19.0	193.6±22.9
Experiments 2 and 3 Cockerels	195.1±23.9	285.0±25.7	294.9±26.8
Experiment 1 Pullets	64.3±14.9	147.4±14.0	97.4±16.8
Experiments 2 and 3 Pullets	117.5±20.8	178.9±19.6	141.8±25.3
	Units of feed required to produce a unit of gain in live weight		
Experiment 1	.49	.26	.31
Experiments 2 and 3	—.02	.36	.25

Figures preceded by minus sign show disadvantages for wheat gray shorts.

Table 6—Ingredients of rations used in experiments 4 and 5 including calcium and phosphorus

Feed	Sample Number	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6
		Percentage of ingredients in rations					
Hard wheat gray shorts	108	20.00	.00	.00	30.00	.00	.00
Soft wheat gray shorts	109	.00	20.00	.00	.00	30.00	.00
Blended wheat gray shorts	110	.00	.00	20.00	.00	.00	30.00
Ground yellow corn	101	56.37	56.37	56.37	46.37	46.37	46.37
Alfalfa leaf meal	104	3.00	3.00	3.00	3.00	3.00	3.00
Meat and bone scrap	113	9.00	9.00	9.00	9.00	9.00	9.00
Dried buttermilk	103	9.00	9.00	9.00	9.00	9.00	9.00
Chick size oyster shell	106	1.50	1.50	1.50	1.50	1.50	1.50
Salt	.....	1.00	1.00	1.00	1.00	1.00	1.00
Cod liver oil	.....	.13	.13	.13	.13	.13	.13
		Calcium and phosphorus analyses of rations					
Percent calcium	.....	1.91	1.90	1.91	1.93	1.90	1.91
Percent phosphorus	.....	.94	.87	.92	.99	.89	.97
Calcium-phosphorus ratio	.....	1:.49	1:.46	1:.48	1:.51	1:.47	1:.51

Comparison of Twenty Percent with Thirty Percent Wheat Gray Shorts

In Bulletin 476 of this station, it was reported that when ten and twenty percent of wheat gray shorts was substituted for a like amount of yellow corn meal, larger gains were made, fewer chicks developed slipped tendons, and less feed was required to produce a unit of gain than when no wheat gray shorts was fed. In experiments 1, 2, and 3 of this bulletin where twenty percent wheat gray shorts was substituted for a like amount of kafir or corn, similar results were reported. The object of this study was to determine whether the substitution of thirty percent of wheat gray shorts would produce larger gains, more completely prevent slipped tendons, and produce more economical gains than twenty percent wheat gray shorts when substituted for a like amount of ground yellow corn in rations containing nine percent meat and bone scrap and nine percent dried buttermilk; these rations contained a higher percentage of calcium and phosphorus than those reported in Bulletin 476 or in experiments 1, 2, and 3 of this bulletin. These higher levels of calcium and phosphorus were used so that the corrective value of wheat gray shorts could be studied under more adverse conditions.

Results

There was very little difference in the slipped tendon index between the lots receiving twenty percent wheat gray shorts and those receiving thirty percent wheat gray shorts when hard wheat shorts was fed. When either soft wheat shorts or blended wheat shorts was fed the lots receiving thirty percent wheat gray shorts had a significantly lower slipped tendon index than the lots receiving twenty percent wheat gray shorts (Tables 7 and 8). Since the hard wheat shorts protected the chicks against slipped tendon better than the soft wheat or blended wheat shorts, the difference in the slipped tendon index between the twenty percent and thirty percent hard wheat shorts could not be as great as with the soft wheat or the blended wheat shorts.

The gains of the cockerels fed the thirty percent wheat gray shorts were larger than those of the cockerels fed the twenty percent wheat gray shorts in both experiments and with all three kinds of shorts, with the exception of the cockerels of experiment 4 receiving blended wheat shorts. When experiments 4 and 5 are combined, the gains of the cockerels fed the thirty percent wheat gray shorts were larger than those of the cockerels fed the twenty percent wheat gray shorts with all three types of shorts. The gains of the pullets fed the thirty percent wheat gray shorts were larger than those of the ones fed the twenty percent wheat gray shorts in both experiments and with all three types of shorts fed, with the exception of the pullets in experiment 5 receiving blended wheat shorts (Table 7). When experiments 4 and 5 are combined, the gains of the pullets fed thirty percent wheat gray shorts were larger than those of the pullets fed twenty percent wheat gray shorts when shorts from hard wheat and shorts from soft wheat were fed; when blended wheat

Table 7—Slipped tendon index, average gain in live weight in grams and feed efficiency experiments 4 and 5

	Hard wheat shorts Sample 108		Soft wheat shorts Sample 109		Blended wheat shorts Sample 110	
	Ration 1 20 percent	Ration 4 30 percent	Ration 2 20 percent	Ration 5 30 percent	Ration 3 20 percent	Ration 6 30 percent
	Slipped tendon index					
Experiment 4	11.1	11.3	22.0	17.0	20.3	19.6
Experiment 5	5.3	4.8	30.6	20.7	28.3	12.5
Mean of experiments 4 and 5	8.2	8.1	26.3	18.9	24.3	16.1
	Average gain in live weight in grams					
Experiment 4 Cockerels	877.6±18.4	957.2±20.1	819.3±15.7	851.8±22.5	875.5±21.1	867.9±16.8
Experiment 5 Cockerels	830.5±17.0	875.6±18.0	773.0±16.9	799.4±22.5	787.2±17.1	867.6±17.4
Mean of experiments 4 and 5	851.8±12.6	914.1±13.8	794.0±11.8	825.6±15.9	828.5±14.0	867.7±11.9
Experiment 4 Pullets	733.1±14.1	775.6±11.4	735.2± 8.4	763.8±15.2	705.9±14.2	726.6±19.3
Experiment 5 Pullets	695.3±12.6	709.9±17.0	659.0±18.9	726.9±14.7	714.2±18.4	683.9±11.7
Mean of experiments 4 and 5	716.8± 9.8	744.3±10.4	701.8±10.2	746.9±10.6	709.7±11.2	706.3±11.4
	Units of feed required to produce a unit of gain in live weight					
Experiment 4	3.66	3.80	3.51	3.62	3.54	3.78
Experiment 5	3.65	3.75	3.71	3.60	3.72	3.70
Mean of experiments 4 and 5	3.66	3.78	3.61	3.61	3.63	3.74

shorts was fed the gains of the pullets fed thirty percent wheat gray shorts were 3.4 ± 16.0 grams smaller than those of the pullets fed twenty percent wheat gray shorts.

Table 8—Summary of advantages of 30 per cent wheat gray shorts over 20 per cent wheat gray shorts

	Advantages* of 30 percent over 20 percent wheat gray shorts		
	Sample 108 Hard wheat shorts	Sample 109 Soft wheat shorts	Sample 110 Blended wheat shorts
	Slipped tendon index		
Experiments 4 and 5	0.1	7.4	8.2
	Average gain in live weights in grams		
Experiments 4 and 5 Cockerels	62.3 ± 18.7	31.6 ± 19.8	39.2 ± 18.4
Experiments 4 and 5 Pullets	27.5 ± 14.3	45.1 ± 14.7	-3.4 ± 16.0
	Units of feed required to produce a unit of gain in live weight		
Experiments 4 and 5	—.12	.0	—.11

*Figures preceded by minus sign show disadvantages for 30 percent shorts.

Comparison of Shorts Milled From Hard, Soft, and Blended Wheat

The object of this study was to determine whether the slipped tendon index, rate of gain, or units of feed required to produce a unit of gain in live weight were influenced by the type of wheat from which the shorts was milled.

Shorts milled from hard wheat, from soft wheat, and from a blend of seventy percent hard wheat and thirty percent soft wheat, were fed in two experiments at levels of twenty and thirty percent. The difference in the amounts of shorts in the rations was made up by ground yellow corn; Table 6 gives the proportions of ingredients in the various rations.

It is seen from Table 1 that hard wheat shorts contains much more protein, fiber, and ash, and less nitrogen-free extract, than shorts milled from soft wheat. The hard wheat shorts contained twice as much magnesium, over twice as much calcium, and about seventy percent more phosphorus than did the shorts from the soft wheat.

Results

The slipped tendon index of the chicks fed hard wheat shorts on both twenty and thirty percent levels was smaller than that of the chicks fed the same levels of soft wheat shorts or blended wheat shorts.

The slipped tendon index of the chicks fed blended wheat shorts on both twenty and thirty percent levels was smaller than that of those fed

Table 9—Comparison of wheat gray shorts from different kinds of wheat

	20 percent wheat gray shorts			30 percent wheat gray shorts		
	Ration 1 Hard wheat shorts	Ration 2 Soft wheat shorts	Ration 3 Blended wheat shorts	Ration 4 Hard wheat shorts	Ration 5 Soft wheat shorts	Ration 6 Blended wheat shorts
			Slipped tendon index			
Experiment 4	11.1	22.0	20.3	11.3	17.0	19.6
Experiment 5	5.3	30.6	28.3	4.8	20.7	12.5
Mean of experiments 4 and 5	8.2	26.3	24.3	8.1	18.9	16.1
			Average gain in live weight in grams			
Experiment 4 Cockerels	877.6±18.4	819.3±15.7	875.5±21.1	957.2±20.1	851.8±22.5	867.9±16.8
Experiment 5 Cockerels	830.5±17.0	773.0±16.9	787.2±17.1	875.6±18.0	799.4±22.5	867.6±17.4
Mean of experiments 4 and 5	851.8±12.6	794.0±11.8	828.5±14.0	914.1±13.8	825.6±15.9	867.7±11.9
Experiment 4 Pullets	733.1±14.1	735.2± 8.4	705.9±14.2	775.6±11.4	763.8±15.2	726.6±19.3
Experiment 5 Pullets	695.3±12.6	659.0±18.9	714.2±18.4	709.9±17.0	726.9±14.7	683.9±11.7
Mean of experiments 4 and 5	716.8± 9.8	701.8±10.2	709.7±11.2	744.3±10.4	746.9±10.6	706.3±11.4
			Units of feed required to produce a unit of gain in live weight			
Experiment 4	3.66	3.51	3.54	3.80	3.62	3.78
Experiment 5	3.65	3.71	3.72	3.75	3.60	3.70
Mean of experiments 4 and 5	3.66	3.61	3.63	3.78	3.61	3.74

these levels of soft wheat shorts, with the exception of the chicks fed thirty percent blended wheat shorts in experiment 4 (Table 9). The gains in weight of the cockerels fed hard wheat shorts on both twenty and thirty percent levels were larger than those of the cockerels fed the same percentages of soft wheat shorts in both experiments 4 and 5. There was no significant difference between the gains made by the pullets receiving the different types of shorts (Tables 9 and 10).

Table 10—Summary of advantages of hard wheat shorts over soft wheat shorts

	Advantages* of hard wheat shorts sample 108, over soft wheat shorts sample 109	
	20 percent shorts	30 percent shorts
	Slipped tendon index	
Experiments 4 and 5	18.1	10.8
	Average gain in live weight in grams	
Experiments 4 and 5 Cockerels	57.8±17.3	88.5±21.1
Experiments 4 and 5 Pullets	15.0±14.1	—2.6±14.8
	Units of feed required to produce a unit of gain in live weight	
Experiments 4 and 5	—.05	—.17

*Figures preceded by minus sign show disadvantages for hard wheat shorts.

The chickens fed soft wheat shorts required slightly less feed to produce a unit of gain in live weight than did those fed hard wheat or blended wheat shorts.

Comparison of Different Levels of Calcium and Phosphorus With and Without Wheat Gray Shorts

The object of these experiments was to compare the effect of three levels of calcium and phosphorus, with and without wheat gray shorts, upon the slipped tendon index, the rate of gains, and the units of feed required to produce a unit of gain in live weight.

Three experiments were conducted on this study; Table 2 gives the rations used in experiment 1 and Table 3 gives the rations used in experiments 2 and 3.

Experiment 1 was conducted in 1934 and experiments 2 and 3 were conducted in 1935. In experiment 1 the chicks were allowed approximately an eleven hour daily feeding period. With experiments 2 and 3 the chicks were allowed a fourteen hour feeding period. For this reason the data for experiments 2 and 3 are studied together in separation from experiment 1.

It is seen from Tables 2 and 3 that the only difference in these rations is that in experiment 1 ground kafir was used and in experiments 2 and

3 ground yellow corn was used. It may be noted from Table 1 that there is more difference in the chemical composition of different samples of the same feeds used in the two different sets of rations than there is between the kafir and corn.

The calcium content of the rations used was higher in 1935 than in 1934. The rations on the low calcium-low phosphorus level contained 1.20 and 1.35 percent of calcium and .56 and .57 percent of phosphorus, with calcium:phosphorus ratios of 1:.47 and 1:.42; those on the high calcium-high phosphorus level contained 1.49 and 1.62 percent of calcium and .69 percent of phosphorus with calcium:phosphorus ratios of 1:.47 and 1:.43; those on the low calcium-high phosphorus level contained 1.23 and 1.35 percent of calcium and .69 and .70 percent of phosphorus, with calcium:phosphorus ratios of 1:.56 and 1:.52.

Results

It is evident from the detailed data of Table 11 and the summary data of Table 12 that low calcium-low phosphorus levels without wheat gray shorts produced decidedly fewer slipped tendons than low calcium-high phosphorus levels. When wheat gray shorts was used on these same mineral levels there was no advantage for either level; evidently, the higher phosphorus level was not high enough to prevent the shorts from protecting the chicks reasonably well against slipped tendons.

Of the chicks receiving low calcium-high phosphorus rations as compared with high calcium-high phosporus rations there was no difference in number of slipped tendons in experiment 1, but in both experiments 2 and 3 there were fewer slipped tendons with the larger amount of calcium. On both of these levels the chicks were almost wholly protected against slipped tendons by wheat gray shorts.

There was a smaller slipped tendon index for the chicks receiving the low calcium-low phosphorus ration than for those receiving the high calcium-high phosphorus ration when no wheat gray shorts was fed. However, when wheat gray shorts was included in the ration, there was very little difference in the slipped tendon index between the chicks on these mineral levels.

In this bulletin, under the heading of twenty percent wheat gray shorts as compared with thirty percent wheat gray shorts, the rations discussed in experiments 4 and 5 were made up to contain considerably more phosphorus than those of experiments 1, 2, and 3; the result was that neither twenty nor thirty percent of any of the types of wheat gray shorts protected the chicks against slipped tendons as efficiently as twenty percent shorts in the rations fed in experiments 1, 2, and 3.

Rations low in calcium and phosphorus produced more rapid gains when no wheat gray shorts was fed and lower gains when wheat gray shorts was fed than did the rations low in calcium and high in phos-

Table 11—Comparison of different calcium and phosphorus levels with and without wheat gray shorts

	With no wheat gray shorts			With wheat gray shorts		
	Ration 4 Low calcium Low phosphorus	Ration 6 Low calcium High phosphorus	Ration 5 High calcium High phosphorus	Ration 1 Low calcium Low phosphorus	Ration 3 Low calcium High phosphorus	Ration 2 High calcium High phosphorus
			Slipped tendon index			
Experiment 1	13.5	39.7	40.7	2.2	0.8	0.0
Experiment 2	22.2	42.2	33.3	2.2	3.0	9.4
Experiment 3	29.4	43.7	39.7	2.4	1.7	0.9
Mean of experiments 2 and 3	25.8	43.0	36.5	2.3	2.4	5.2
			Average gain in live weight in grams			
Experiment 1 Cockerels	659.7±15.2	690.6±14.1	707.4±15.2	810.2±20.1	837.9±12.8	901.0±14.0
Experiment 2 Cockerels	783.3±22.2	757.3±31.8	801.6±25.0	984.9±25.4	1072.3±23.0	1103.3±32.4
Experiment 3 Cockerels	829.4±27.9	818.4±21.0	809.7±33.6	1011.1±21.3	1079.8±27.5	1097.8±18.8
Mean of experiments 2 and 3	805.1±17.6	791.4±18.4	805.3±20.3	1000.2±16.2	1076.4±18.0	1100.2±17.5
Experiment 1 Pullets	613.6±11.1	562.6± 8.4	607.6±10.7	677.9± 9.9	710.0±11.3	705.0±13.0
Experiment 2 Pullets	691.9±23.7	700.3±14.1	773.8±16.7	808.9±24.2	880.7±20.1	886.5±19.1
Experiment 3 Pullets	721.3±19.7	667.5±18.2	697.4±13.8	840.7±17.8	846.4±23.1	856.2±39.2
Mean of experiments 2 and 3	710.5±15.1	682.6±11.8	728.7±11.3	828.0±14.3	861.5±15.6	870.5±22.6
			Units of feed required to produce a unit of gain in live weight			
Experiment 1	4.26	4.12	4.05	3.77	3.86	3.74
Experiment 2	4.26	4.38	4.18	4.34	3.95	3.93
Experiment 3	3.99	4.03	4.10	3.95	3.74	3.85
Mean of experiments 2 and 3	4.13	4.21	4.14	4.15	3.85	3.89

Table 12—Summary of advantages of different calcium and phosphorus levels

	Advantages* of various mineral levels over other levels					
	Low calcium and low phosphorus rations over low calcium and high phosphorus rations		High calcium and high phosphorus rations over low calcium and high phosphorus rations		High calcium and high phosphorus rations over low calcium and low phosphorus rations	
	No wheat gray shorts	Wheat gray shorts	No wheat gray shorts	Wheat gray shorts	No wheat gray shorts	Wheat gray shorts
			Slipped tendon index			
Experiment 1	26.2	—1.4	—1.0	0.8	—27.2	2.2
Experiments 2 and 3	17.2	0.1	6.5	—2.8	—10.7	—2.9
			Average gain in live weight in grams			
Experiment 1 Cockerels	—30.9±20.7	—27.7±19.0	16.8±20.7	63.1±23.8	47.7±21.5	90.8±24.5
Experiments 2 and 3 Cockerels	13.7±27.4	—76.2±25.1	13.9±25.5	23.8±24.2	0.2±26.9	100.0±24.1
Experiment 1 Pullets	51.0±13.6	—32.1±17.2	45.0±13.9	—5.0±15.0	—6.0±15.4	27.1±16.3
Experiments 2 and 3 Pullets	27.9±16.3	—33.5±27.5	46.1±19.2	9.0±21.2	18.2±18.9	42.5±26.7
			Units of feed required to produce a unit of gain in live weight			
Experiment 1	—.14	.09	.07	.12	.21	.03
Experiments 2 and 3	.08	—.30	.07	—.04	—.01	.26

*Figures preceded by the minus sign show disadvantages for the calcium and phosphorus levels in question.

phorus (Tables 11 and 12). With both cockerels and pullets, the high calcium-high phosphorus ration produced greater gains when no wheat gray shorts was fed than the low calcium-high phosphorus ration, except for the cockerels of experiment 3 on the low calcium-high phosphorus ration. When wheat gray shorts was included in the ration, the high calcium-high phosphorus ration produced greater gains than the low calcium-high phosphorus ration in both cockerels and pullets with the exception of the pullets in experiment 1 (Table 11). There are not any consistent differences in the gains of the chickens between those fed the low calcium-low phosphorus ration and those fed the high calcium-high phosphorus ration when no wheat gray shorts was fed (Tables 11 and 12). When wheat gray shorts was included in the ration, the high calcium-high phosphorus ration produced higher gains than the low calcium-low phosphorus ration in both cockerels and pullets (Tables 11 and 12).

When no wheat gray shorts was fed there was very little difference in the units of feed required to produce a unit of gain in live weight between the low calcium-low phosphorus, low calcium-high phosphorus, and high calcium-high phosphorus rations. When twenty percent wheat gray shorts was included in the ration, the low calcium-low phosphorus ration required more units of feed to produce a unit of gain in live weight, than did the low calcium-high phosphorus ration, except in experiment 1. There is very little difference in the units of feed required to produce one unit of gain between the low calcium-high phosphorus ration and the high calcium-high phosphorus ration (Tables 11 and 12). The data seem to indicate that chicks are able to utilize larger amounts of calcium and phosphorus when twenty percent wheat gray shorts is included in the ration.

Discussion

Twenty percent wheat gray shorts in rations containing from 1.20 to 1.62 percent calcium and from .56 to .57 percent phosphorus produced more rapid gains and fewer slipped tendons, and required less feed to produce a unit of gain in live weight in experiments 1, 2, and 3, regardless of the amount of calcium and phosphorus in the rations, than did the rations not containing wheat gray shorts. This is in agreement with the work of Graham and associates (3), Wilgus and associates (19), Branion (1), Milby (11), Titus and Ginn (17), and Sherwood and Couch (14).

In experiments 4 and 5 rations containing 1.90 to 1.93 percent calcium, .87 to .99 percent phosphorus, and twenty or thirty percent wheat gray shorts, produced more slipped tendons than did the rations used in experiments 1, 2, and 3. This was probably due to the larger percentage of phosphorus in the ration, and is in agreement with the work of Insko and associates (9), and Milby (11).

Rations containing thirty percent wheat gray shorts produced more rapid gains but required slightly more feed to produce a unit of gain in live weight in experiments 4 and 5, than did twenty percent wheat gray shorts. Twenty or thirty percent hard wheat shorts in the rations of experiments 4 and 5 produced more rapid gains and fewer slipped tendons than shorts milled from soft wheat or blended wheat. Although the same percentage of ingredients was used in experiments 1, 2, and 3, the rations of experiments 2 and 3 contained larger percentages of calcium than the rations used in experiment 1. This is due to the variation in the composition of the individual feeds, since a different lot of feed was used for experiment 1 than for experiments 2 and 3.

Low calcium-low phosphorus rations (1.20-1.34 percent calcium and .56-.58 percent phosphorus), low calcium-high phosphorus rations (1.21-1.35 percent calcium and .69-.72 percent phosphorus), and high calcium-high phosphorus rations (1.49-1.62 percent calcium and .69-.72 percent phosphorus) were fed both with and without wheat gray shorts in experiments 1, 2, and 3. The presence of wheat gray shorts in the rations had a greater effect in increasing the rate of gain, reducing the number developing slipped tendons, and reducing the units of feed required to produce a unit of gain in live weight than did the variation in the percentages of calcium and phosphorus. The low calcium-low phosphorus ration produced fewer slipped tendons than the low calcium-high phosphorus ration or the high calcium-high phosphorus ration when no wheat gray shorts was fed. The high calcium-high phosphorus ration produced more rapid gains than the low calcium-low phosphorus ration or the low calcium-high phosphorus ration, and required less feed to produce a unit of gain than the low calcium-low phosphorus ration when wheat gray shorts was included. These results agree with those of Insko and associates (9), Milby (11), and Hammond (4).

Several investigations including those of Graham and associates (3), Titus (16), and Sherwood and Fraps (15), have tried to determine whether results similar to those described in this bulletin might not be caused by a vitamin. All of these investigators have made various extracts of mill feeds known to be of value in preventing slipped tendons in an endeavor to isolate and identify this corrective substance. As yet, no positive results have been published. The experiments in this bulletin were not planned to test the effects of organic and inorganic phosphorus in correcting slipped tendons. Rations which contained wheat gray shorts and which protected the chicks reasonably well contained a larger proportion of organic to inorganic phosphorus than rations not containing wheat gray shorts. There may be other substances contained in the wheat gray shorts which vary along with the phosphorus, so that it is impossible to conclude that the results are caused by the relation of organic to inorganic phosphorus in these rations.

Summary and Conclusions

1. Chick rations containing twenty percent wheat gray shorts in place of a like amount of corn or kafir produced more rapid gains and fewer slipped tendons, and required less feed to produce a unit of gain, than did rations not containing wheat gray shorts.

2. The substitution of thirty percent wheat gray shorts for a like amount of corn in chick rations produced more rapid gains but required more feed to produce a unit of gain than the substitution of twenty percent wheat gray shorts for a like amount of corn.

3. Wheat gray shorts milled from hard wheat was of more value as an ingredient in chick rations in producing more rapid gains and preventing slipped tendons, but required more feed to produce a unit of gain, than shorts milled from soft wheat.

4. In three rations with different calcium-phosphorus levels with and without shorts, the presence of wheat gray shorts in the ration had a greater effect on gain in weight, prevention of slipped tendons, and units of feed required to produce a unit of gain, than did the various calcium phosphorus levels.

5. Rations containing 1.90-1.93 percent calcium and .87-.97 percent phosphorus with twenty and thirty percent wheat gray shorts did not protect the chick against slipped tendons as well as rations containing 1.20-1.62 per cent calcium and .56-.57 percent phosphorus with twenty percent wheat gray shorts.

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